Three-dimensional numerical study of heat transfer and mixing enhancement in a circular pipe using self-sustained oscillating flexible vorticity generators

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Résumé en anglais	In this paper, heat transfer and mixing performances are studied using three-dimensional numerical simulations of fluid-structure interactions. To this aim, a multifunctional heat exchanger/reactor geometry is investigated, consisting of a circular pipe where five arrays of four equally spaced trapezoidal vortex generators are inserted and inclined in a reversed position opposite to the flow direction with an angle of 45° with respect to the pipe wall. A periodic rotation of 45° is applied to the tabs arrays. Two cases are numerically studied: one using flexible vortex generators (FVG) that deform due to fluid forces applied on the structures and the other using conventional non deformable rigid vortex generators (RVG). For the FVG configuration, the tabs oscillate without addition of any external source of energy except that of the fluid flow itself, leading to a passive but dynamic way to perform vortex formation to disturb the flow. Both flow regimes are laminar with a constant Reynolds number of 1500. The flow structures are analyzed using the proper orthogonal decomposition (POD) technique and the effect of tabs oscillation on vortices creation, suppression and dislocation is highlighted. The effect of self-sustained free elastic tabs oscillation on heat transfer and mixing performances is numerically investigated by comparing the FVG with its corresponding RVG configuration. The Nusselt number comparison shows that the free tabs oscillation can improve the overall heat transfer of about 118% with respect to an empty pipe whereas it is about 97% for the RVG study. Finally, to assess the mixing performance, the transport of a passive scalar initially divided into two different concentrations in the pipe is numerically analyzed through the mixing index value. The FVG configuration shows a drastic improvement of the mixture quality at the exit of the pipe with an increase of 195% with respect to the RVG case, leading to much shorter and compact mixers and reactors.
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